Design and Construction of a 2000-Ton Slipway.

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(*Member*).*

General Description of Slipway.

In 1938, proposals were made for the construction of a new and larger slipway at Fremantle, the existing one on the north side being in bad condition and limited to 850 tons.

Owing to the restricted area of the harbour and proposals for future harbour extension, the possible sites were limited, and the site chosen at Arthur's Head on the south side was the best possible, but is not quite free from rough weather conditions and a cross ebb during winter floods.

The capacity of the slipway was fixed at 2,000 tons, and authority to proceed with construction was given in September, 1940.

The original proposal was for a slipway 740 ft. long, with telescopic cradle 190-250 ft. long, with draft of 10 ft. over keel blocks at forward end of cradle. Of this length, 460 ft. were below L.W. and 280 ft. above. The normal tidal variation is very small, and L.W. datum is taken for the necessary drafts.

During construction, in order to accommodate certain naval vessels, a request was made for the draft to be increased to 17 ft. at a distance of 76 ft. from the forward end of cradle, or 13 ft. 9 in. on the forward blocks, which entailed an extension of the ways below water for a distance of 135 ft., and at the same time the shore endways above water were extended 73 ft. to enable longer vessels to be accommodated, as service vessels are generally longer than merchant vessels of equal tonnages. The overall length is now 948 ft., 595 ft. being below water, with the outer end at a rail level of 29 ft. 9 in. below L.W. At the same time, the length of cradle was increased so that a maximum length of 300 ft. was obtainable, but at present the cradle is 289 ft. long over keel blocks. A grade of 1 in 20 was fixed for the incline of the ways, which consist of two centre rails 1 ft. 8 in. centre to centre, with cast steel pawl rack between, and two single side rails, the centre of each being 14 ft. from the centre line of slipway. The rails are a special flat bottomed section, 112 lb. per lin. yd., 4 in. high, with a web $1\frac{1}{2}$ in. thick, and are fixed on special cast iron chairs set at 2 ft. 6 in. centres, which also take the rail joints, a lug being cast on one side to hold the bottom flange, and a $\frac{5}{8}$ in. clamp plate held down by two 1-in. bolts on the other. The cast steel pawl rack has vertical teeth 2 in. high, 6 in. pitch, and extends from 338 ft. 6 in. below L.W. to 330 ft. above L.W. The pawl rack sections are 7 ft. 6 in. long, each held down by four pairs of 1-in. rag bolts.

The maximum load on the foundations of centre way is 4 tons per sq. ft., and bearing tests which were carried out on the rock on the foreshore were satisfactory, giving 6 tons per sq. ft. without settlement. The foundations, which are concrete throughout, are on rock, one section of 100 ft. mentioned later, where rock was shattered, being piled. The width of centre way foundation is 4 ft. 6 in., and the side ways 2 ft., the chairs, pawl racks, and their holding down bolts were concreted *in situ*. In order to maintain the thread and nut of these bolts from corrosion, and facilitate replacement of rails when required, a domed cap was welded on the top of the nut and the thread and inside of cap nut were coated with No. 3 Resqu steel paint, the outside of rails, plates, etc., being painted with No. 2 Resqu steel paint. To prevent creep in the rails, lugs were welded to the underside of the rail at the upper end of slipway and grouted up, the concrete being flush with the rail throughout. A stop for end of cradle is fixed at the bottom end of the slipway to prevent the cradle running off the rails, and this is combined with the foundations for the pulleys for downhaul rope.

Cradle.

The cradle consists of seven carriage sections, with five inserts on centre way only; the five middle carriage sections mount the bilge arms which carry the sliding bilge blocks (fifteen on each side), four extra bilge arms being fitted later to two of the

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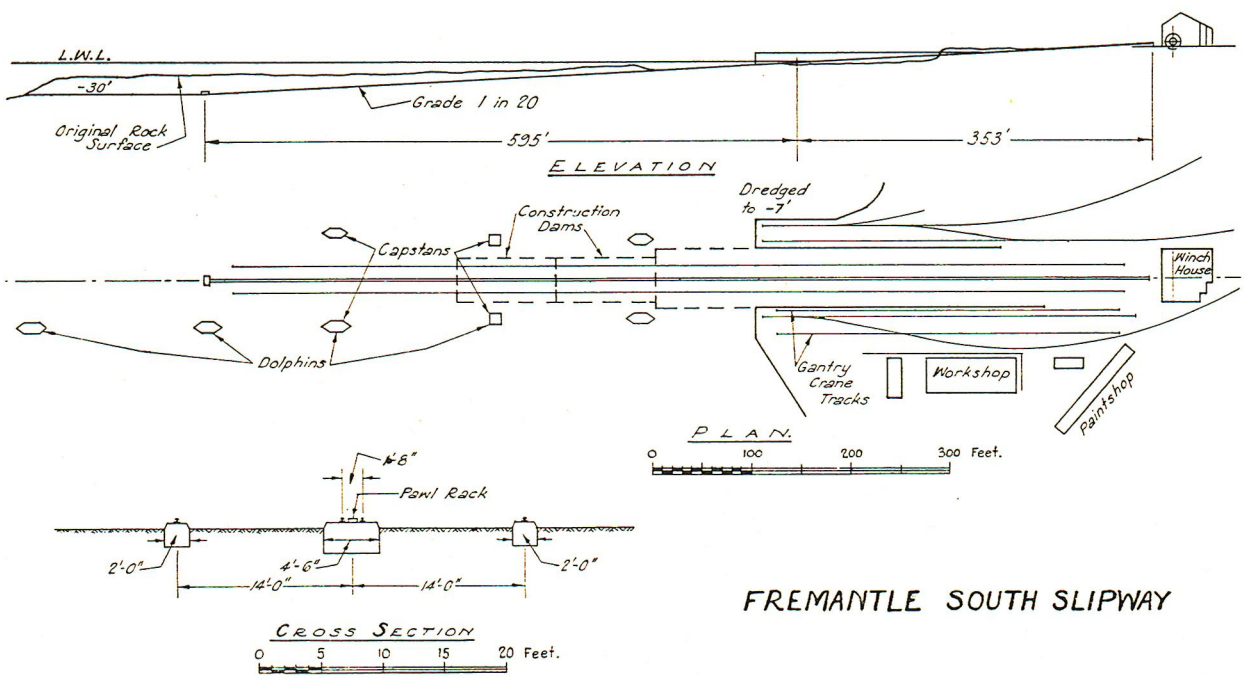

Fig. 1.—Sketch Plan and Elevation of Slipway.

inserts. The bilge blocks are fitted with pawl racks. The carriage sections are coupled together by drawbar links secured by placing special alloy steel pins, 5 in. diameter, through the centre girder.

There are 430 rollers under the centre girders and 146 rollers under side girders, a total of 576. The rollers are of cast steel, 9 in. dia. on the tread, with single flanges of 12 in. dia. and 4 in. dia. axles. Those under centre girder are $4\frac{1}{2}$ in. wide on tread, and under side way girders $3\frac{1}{2}$ in. wide. Each carriage section is fitted with a pawl.

The centre of the carriage was designed to take the whole load at a maximum load concentration of 16 tons per lin. ft., and the sides to take 20 per cent. each.

Axle bearings are cast iron, with G.M. bushes and grease lubrication, the underside having a felt pad to keep grease on the axle and prevent sand and grit adhering to it.

Steel ploughs to clear the rails of silt or obstruction are fitted at the lower end of the mid and side girders, with $\frac{1}{4}$ in. clearance above rails.

The distribution of the pressure of a ship's keel over the blocks is a very complex problem. The length of overhang of some vessels causes concentrated loads, and at the initial slipping stages concentrated loads at the forward end of keel are exerted until the whole of the keel is seated on the blocks. These areas of concentrated loads on the cradle vary with various vessels. One vessel recently slipped was 345 ft. long, having 212 ft. straight keel with 60 ft. overhang forward and 73 ft. overhang aft.

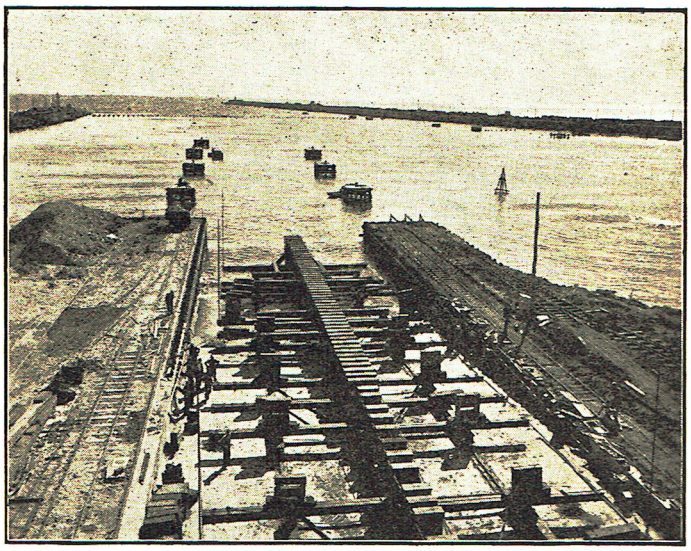

Fig. 2.—View looking West, Showing Cradle and Dolphins.

The keel blocks which are 15 in. square karri timber, at 2 ft. centres where the major loads are anticipated, have been cribbed up on timber bearers to a grade of either 1 in 50 or 1 in 96, depending on the length of keel of vessel, so that the keel sits throughout with the minimum amount of forward movement of the cradle, and therefore minimum time and reduced stresses. This and other alterations have increased the weight of cradle from the original design of 143 tons to 290 tons.

Construction.

Dredging.—From L.W. the natural surface approximated to the grade of the slipway for a distance of 150 ft.; thereafter the rock had to be dredged out, being 12 ft. 6 in. deep at the end of original design, but 16 ft. at the end of the extension. This rock was drilled and blasted at 5-ft. centres over a width of 50 ft., and 25,434 cu. yd. of rock were dredged out; the upper section in shallow water was removed by floating grab dredge and punts, and where there was flotation, by bucket dredger.

A start was made by constructing a timber gantry, 300 ft. long, to carry a crane track to a point 150 ft. beyond L.W. mark. This was to give access for the construction of a coffer dam, 200 ft. by 45 ft. wide, divided into two equal sections, so that the upper length of the ways could be constructed in the dry, thereby assuring better foundations over the length where the heavier loads would be carried.

The dam was constructed of steel sheet interlocking piling which was driven to a minimum of 6 ft. into the rock, strutted internally with timbers that were also secured to timber piling which carried the gantry forward over the work. This sheeting proved very effective for the walls of the dam, but the water making through the rock bottom was greater than anticipated. This was due to the presence of pipes of limestone and veins in the rock, carrying large quantities of water often with sand in suspension, and it was found necessary several times to allow the water to level up, and then to grout the pipes by tremie, allowing time for the concrete to set before pumping out again. Two centrifugal pumps, 15 in. dia., were necessary to cope with the water. The first upper 100 ft. of the dam was pumped out and concrete ways laid, complete with chairs, pawl rack, and rails. This was allowed to flood and the second section then pumped out, after which excavation and concreting of the ways proceeded, but a few days before completion, and after work in this section had been carried on for a period of seven weeks, the dam collapsed.

It is considered that the rock bed was weakened through the sand being washed out of the veins in the rock, and that the weaker portions of rock were then lifted due to the hydrostatic head. There were areas of softer and laminated rock, but no evidence of cavernous areas. The collapse lifted the ways already concreted and shattered the rock foundations to such an extent that it was decided to reconstruct this section by working under water. After clearing the bottom, probes were put down to ascertain the depth of shattered rock; timber bearing piles were then driven under the line of the ways to solid rock. Precast concrete casings, 5 ft. 7 in. × 5 ft. 3 in. × 1 ft. 6 in. for centre way, and 7 ft. 7 in. × 5 ft. 3 in. × 1 ft. 6 in. for side ways, with 4 in. thick walls, were then placed over a group of four piles at 15 ft. centres, and after being levelled up were concreted through tremie pipe to graded level for seating of reinforced concrete precast beams. The beams were complete with chairs for rails and, where required, pawl racks, which were accurately lined and levelled; the beam for centre way was 2 ft. 11 in. × 1 ft. 3 in. section, and side way 1 ft. 6 in. (top) × 2 ft. 3 in. (bottom) × 1 ft 3 in. (deep) section, both 14 ft. $11\frac{1}{2}$ in. long with the ends tongued and grooved. After final levelling the spaces between foundation blocks were shuttered, and concreting by tremie was completed, forming the foundation from the intermediate timber piles to the reinforced concrete beam.

The outer ends of the ways, including the extension, were constructed in a similar manner without piling, the casings being set on the dredged rock bed. The casings, which were 5 ft. 0 in. × 3 ft. 9 in. × 1 ft. 6 in. for centre ways and 3 ft. 9 in. × 3 ft. 6in. × 1 ft. 6 in. for side ways, were set at 10 ft. centres, and the reinforced concrete beams were 2 ft. 8 in. × 1 ft. 3 in. section for centre, and 1 ft. 6 in. × 1 ft. 3 in. for side way, 20 ft. long, the bottom centre way beam having a buffer stop 2 ft. high, cast integral to take the end of cradle.

During this outer construction, as the steel sheet piling was drawn it was redriven forming a dam between the first section completed and the shore, the inshore ends remaining to form the retaining walls of the ground carrying the crane tracks on either side; these walls were 60 ft. apart and were considered ample for the beam of any vessel using the slip, at the same time allowing the cranes available to operate.

Haulage.—Haulage is by a direct pull on a double drum, the bight of the rope passing round a cast steel pulley, 6 ft. in dia., attached to the leading end of the cradle. The ends are secured to the two helically grooved drums (right and left-hand) round

which the rope is wound. A third drum takes the down-haul rope which passes round twin cast steel pulleys, 2 ft. dia. at 2 ft. 10 in. centres, securely mounted on a block at the extreme lower end of centre way. The main hauling steel wire rope is 10½ in. in circumference, 1,400 ft. long, the down-haul wire being 4 in. circumference.

The haulage winch is electrically driven by two motors of 125 h.p. at 775 r.p.m., fitted with solenoid brakes.

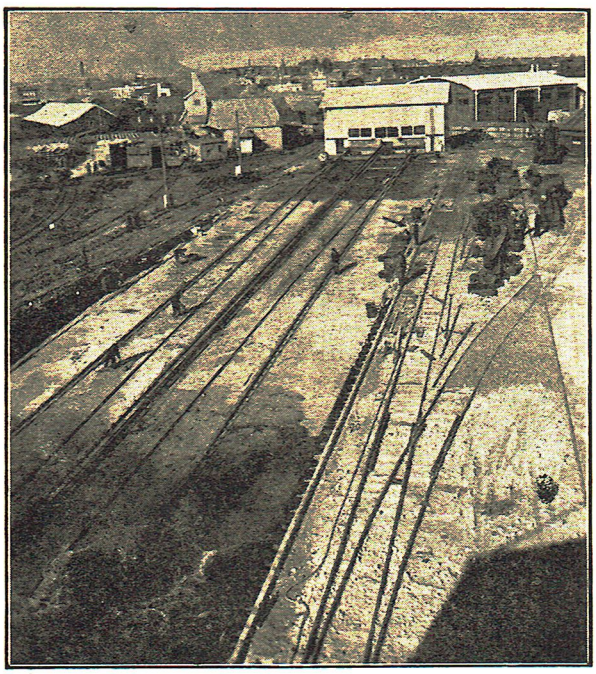

Fig. 3.—View looking East, showing Tracks and Winch House.

The first reduction is by double helical machined teeth with a ratio of 1 : 6.95, the pinion being forged steel and the wheel cast steel. The second reduction is straight spur cast steel machined teeth with ratios of 1 : 3 and 1 : 6, the two pinions being on a sliding keyway to provide haulage speeds of 20 and 10 ft. per minute, as required. The third reduction is straight spur cast steel (ratio 1 : 6), and the fourth reduction to drive on drum is also straight spur cast steel with ratio of 1 : 5.88; the final pinion is also on sliding keyway. Clutches are provided, of the two-jaw type, to couple down-haul drum to the main haulage drums, and also for the cross drive.

Dolphins.

Timber piled dolphins, three on north side and three on south side, are provided for centering the vessel on the cradle, the outer two on each side being fitted with electric capstans; there are also two guide dolphins on the south side for vessels to lie against before warping onto the slipway.

Services.

On the south side an electric travelling gantry crane is provided, capable of lifting 6 tons at 46 ft. radius, and placing load on the deck of a vessel on the slip. A 5-ton steam travelling crane is located on the north side.

For vessels requiring electricity for lighting, ventilating, refrigeration, and cooking, a direct current generator is installed in the winch house, capable of supplying 500 amp. at 110 or 220 volts. In addition, points are provided on each side of slipway for portable lights, and also for plugging in welding sets or electric tools.

An air compressor, of 300 cu. ft. capacity at 100 lb. per sq. in. pressure, supplies air to four double points on either side.

Three fire hydrants are fixed on each side, and three triple connections for flooding chambers on vessels, if required.

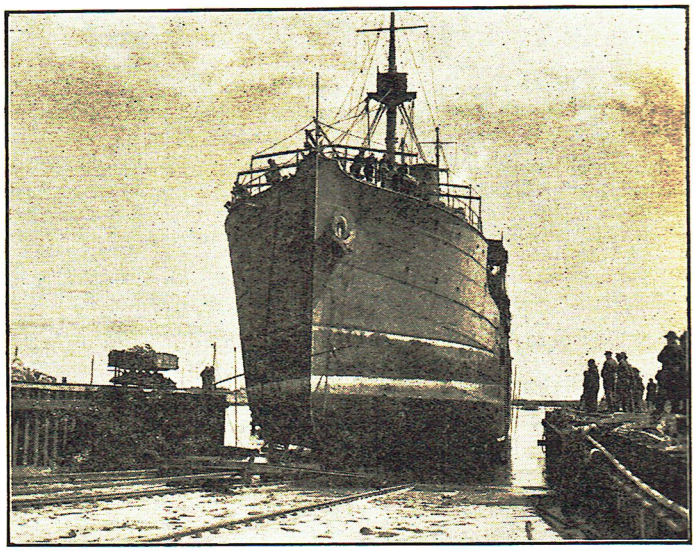

Fig. 4.—First Vessel to use Slipway—"S.S. Chungking."
(Gross 1967 tons, 285 ft. long, 44 ft. beam.

Small stores and workshop are erected on the south side, with paint stores and paint mixing room. Lavatories and showers are available for crews living on board vessels.

The slipway was first used on 22nd September, 1942, and in a period of three years* has accommodated 282 vessels of an aggregate tonnage of 343,691.

Services Packaging Code Issued.

Application to Post-War Industry.

Although prepared in the first instance to cover the packaging of goods and equipment for Service use, the S.A.A. Packaging Code for Service Stores will have a useful application in peace-time in the packing of civilian goods for shipment to countries in the tropical zone. This code, numbered S.A.A. Int. 60, has just been issued in the Interim Series by the Standards Association of Australia.

Framed by Inter-Service Committee No. 1, working under the aegis of the Scientific Liaison and Information Bureau, the code provides a complete guide to the packaging of Service stores. It is intended to cover the contingency that the goods will meet additional hazards in transit under war conditions, as well as the normal risks of transport and storage in peace time.

Many of these hazards are likely to be met in the immediate post-war period, particularly in rehabilitation work. For example, handling by inexperienced personnel, adverse conditions during transport, unshipping at ports without proper handling facilities, storage in the open under tropical conditions—all these circumstances require the greatest care in the packaging of perishable or easily damaged commodities.

The code has sections dealing with definitions and methods of test, packaging requirements (i.e., as to transport, marking, protection from mechanical damage and moisture); packaging methods are dealt with in detail, with additional sections on outer and inner containers and packaging materials. The code is well furnished with illustrations showing in detail the application of the various packaging methods, and a great deal of information is given in ready reference form by means of tables. A separate guide sheet, setting out eight basic steps in the choice of packaging methods, with reference to the appropriate sections of the code, is included.

A number of useful appendices give additional information on such matters as cleaning of metallic parts, de-rusting and descaling of iron and steel, drying of metallic stores after cleaning, application of temporary corrosion preventives, and details of corrosion-preventive, waterproof and moisture-proof methods of packaging.

Copies of the code may be purchased from the Headquarters of the Standards Association of Australia, Science House, Gloucester and Essex Streets, Sydney, or from any of the Association's branch offices in capital cities of the Commonwealth, and at Newcastle, N.S.W.

*Figures as published here have been adjusted since presentation of the paper.